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PATENT APPLICATION

ATTORNEY DOCKET NO. 10971414-1

IN THE U.S. PATENT AND TRADEMARK OFFICE
Patent Application Transmittal Letter

ASSISTANT COMMISSIONER FOR PATENTS
Washington, D.C. 20231

Sir:

Transmitted herewith for filing under 37 CFR 1.53(b) is a(n): (X) Utility ( ) Design
(X) original patent application,
( ) continuation-in-part application

INVENTOR(S): **Julian A. Carey, et al.**

TITLE: **A Surface Mountable LED Package**

Enclosed are:

(X) The Declaration and Power of Attorney. (X) signed ( ) unsigned or partially signed

(X) 2 sheets of drawings (one set)

( ) Information Disclosure Statement and Form PTO-1449 ( ) Associate Power of Attorney

( ) Priority document(s) ( ) (Other) _____ (fee $_____)

CLAIMS AS FILED BY OTHER THAN A SMALL ENTITY				
(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) TOTALS
TOTAL CLAIMS	19 — 20	0	X $ 22	$ 0
INDEPENDENT CLAIMS	1 — 3	0	X $ 82	$ 0
ANY MULTIPLE DEPENDENT CLAIMS	0		$ 270	$ 0
BASIC FEE: Design ($330.00); Utility ($790.00)				$ 790
TOTAL FILING FEE				$ 790
OTHER FEES				$ 0
TOTAL CHARGES TO DEPOSIT ACCOUNT				$ 790

Charge $ 790 to Deposit Account 08-2025. At any time during the pendency of this application, please charge any fees required or credit any over payment to Deposit Account 08-2025 pursuant to 37 CFR 1.25. Additionally please charge any fees to Deposit Account 08-2025 under 37 CFR 1.16, 1.17,1.19, 1.20 and 1.21. A duplicate copy of this sheet is enclosed.

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Date of Deposit 11/5/98

I hereby certify that this is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231.

By D Baker

Typed Name: **Dianna Baker**

Respectfully submitted,

Julian A. Carey, et al.

By Pamela Lau Kee

Pamela Lau Kee

Attorney/Agent for Applicant(s)
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Date: 5 November 1998

Telephone No.: **408-553-3059**

Rev 02/98 (TransNew)

- Attach as First Page to Transmitted Papers -

A SURFACE MOUNTABLE LED PACKAGE

Field of the Invention

The present invention is directed towards the field of packaging light emitting diodes.

BACKGROUND OF THE INVENTION

Most light emitting devices (LEDs) emit incoherent light. One performance measure of an LED is photometric efficiency, e.g. the conversion of input energy into visible light. Photometric efficiency is inversely proportional to the junction temperature of the LED. A major concern of the LED package designer is keeping the die cool to provide good overall performance.

For low power LEDs, e.g. ≤ 200 mW, or die with small area, a large optical cavity size limits the ability to meet the desired reliability conditions. A smaller than optimum cavity size reduces the light extraction efficiency, e.g. the amount of generated light that exits the device. The prior art packages e.g. T1-3/4 and SnapLED, use cast epoxy as the hard encapsulant. The cast epoxy provides both optical and structural functionality. A prior art package design for an LED is shown in Figure 1. The die is seated at the base of the optical cavity. A hard encapsulant, e.g. rigid unfilled epoxy, fills the optical cavity. Because the die, the optical cavity, and the encapsulant have different thermal coefficients, they expand and contract at different rates during operation. This places a high mechanical stress on the LED. In addition, the prior art packages lack thermal isolation between the electrical and the thermal paths because the electrical leads are the primary thermal paths. As a result, the packaged die are subject to thermal stresses from the temperature cycling, especially during assembly into end products.

These problems are exacerbated as the die increases in area or input power. Because a device having a larger junction area, e.g. > .25mm^2 requires a larger optical

element than a small die, e.g. $<<$ .25 mm^2, to provide comparable light extraction efficiency, a large optical cavity is necessary. The mechanical stress applied to the LED increases with the volume of the encapsulant. In addition, the stress increases as the packaged LED is exposed to temperature cycling and high moisture conditions. The accumulated mechanical stresses reduce the overall LED reliability.

Since prior art packages use their electrical leads as primary thermal paths, the high thermal resistance of these paths combined with the high thermal resistance of the external system creates high junction temperatures, when power dissipation increases, e.g. $\geq$ 200mW. High junction temperature contributes to accelerating the irreversible loss of photometric efficiency in the LED chip and also accelerates processes that contribute to the failure of mechanical integrity of the LED package.

None of the available LED packages provide reliable optically efficient operation for applications approaching LED average input power of 0.2 W, especially when operating under high ($>$ 35%) duty factors or long pulse widths $>$ 1 second.

SUMMARY OF THE INVENTION

The present invention is an LED package that has separate optical and structural functionality. A heat-sinking slug is inserted into an insert-molded leadframe. The insert-molded leadframe consists of a patterned metal part, overmolded by a filled plastic material to provide structural integrity. The slug may include an optional reflector cup. The LED die is mounted directly or indirectly via an electrically insulating and thermally conducting sub-mount to the slug. Bond wires extend from the LEDs to metal leads that are electrically and thermally isolated from the slug. An optical lens may be added by mounting a pre-molded optically transparent thermoplastic lens and a soft optically transparent encapsulant or by casting an optically transparent epoxy to cover the LED or by a cast optically transparent epoxy lens over soft optically transparent encapsulant. The soft optically transparent encapsulant is a soft material that provides low stress or cushioning to the LED die.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a prior art LED assembly.

Figure 2 illustrates an embodiment of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Figure 2 illustrates an embodiment of the present invention, an LED package that has decoupled optical and structural functionality. A heat-sinking slug 10 is placed into an insert-molded leadframe 12. The insert-molded leadframe 12 is a filled plastic material molded around a metal frame that provides an electrical path. The slug 10 may include an optional reflector cup 14. The light-emitting diode (LED) die 16 is mounted directly or indirectly via a thermally conducting sub-mount 18 to the slug 10. Bond wires extend from the LED 16 and the submount 18 to metal leads on leadframe 12 that are electrically and thermally isolated from the slug 10. An optical lens 20 may be added by mounting a pre-molded thermoplastic lens and an encapsulant (not shown) or by casting epoxy to cover the LED or by a cast epoxy lens over the encapsulant (not shown). The encapsulant is preferably a soft material that provides low stress or cushioning to the LED die. Because the LED die is thermally coupled to the heat-sinking slug, the die can be maintained at a junction temperature lower than conventional packages. The lower operating temperature maintains reliability and performance under high-power conditions because the die is not subject to high thermal stress.

The heatsinking slug 10 is isolated thermally from the leadframe 12. If an insulating submount 18 is used, then the slug 10 is electrically insulating. Hence, the slug 10 may be attached to an external heat sink (not shown) with minimal thermal resistance to prevent a thermal build-up within the package. The massive slug 10 provides a low thermal resistance path to conduct heat away from the LED die 16. While the preferred embodiment employs a copper slug, other suitable materials include thermally conductive materials such as diamond, silicon, aluminum, molybdenum, aluminum nitride, aluminum oxide, or composites and alloys thereof. Alternatively, composites of molybdenum-copper and tungsten-copper may be used.

The submount 18 provides a thermally conducting path and thermal expansion buffer between the slug material and the LED die. It preferably has a thermal

coefficient of expansion comparable to the LED die. The submount 18 may be electrically conducting or insulating.

The insert-molded leadframe 12 is a patterned metal part that provides high electrical conductivity but only low thermal conductivity. The leadframe may be over-molded by a plastic structural part that provides low thermal conductivity and electrical insulation. The insulating part of the leadframe is a filled plastic material that provides structural integrity. The strong plastic body provides the structural integrity of the package and has hardness on the order of Durometer Shore 50-90 D. Separating the optical and structural functions allows the package to maintain optical quality without compromising its structural integrity.

The encapsulant is a soft optically transparent material having a refractive index > 1.3, e.g. silicone, liquid or gelatinous optical compound, and fills the optical path between an LED die 16 and the optical lens 20. The soft optically transparent material protects the LED die 16. The soft encapsulant has a hardness less than Durometer Shore 10 A.

The optional reflector cup 14 is made of thermally conductive materials that have been plated for reflectivity. The optional reflector cup 14 may be made of thermally conductive materials that have been coated for reflectivity. Similar to the slug 10, suitable thermally conductive materials from which the optical surfaces of the reflector cup may be composed include thermally conductive materials such as silver, copper, aluminum, molybdenum, diamond, silicon, alumina, aluminum nitride, aluminum oxide, and composites thereof. Unlike the slug, the reflector cup walls may also be made of thermally insulating materials, e.g. plastics with reflective coatings. Alternatively, the walls may be formed by the un-coated surface of the optical plastic lens shell arranged such that the exterior optical surface presents a reflective surface by Total Internal Reflection (TIR) by virtue of the angle of incidence to the light rays from the chip to the surface and a high to low refraction index step change at the surface. The refraction index step change is ≥0.3.

In many preferred embodiments the cup has been coated with silver. Other reflective material coatings may be used such as aluminum, gold, platinum, dielectric coated metals such as aluminum, silver, gold, or pure dielectric stacks.

CLAIMS

We claim:

1. A package for a die comprising:

a leadframe, having a cavity, being operative to provide structural integrity;

a slug of thermally conductive material, positioned at the base of the cavity; and

a lens, positioned within the leadframe and opposing the cavity, being operative to provide optical functionality.

2. A package, as defined in claim 1, further including a submount of thermally conductive material, connected to the slug.

3. A package, as defined in claim 2, wherein the thermally conductive material is selected from a group that includes pure materials, compounds, and composites of silver, copper, diamond, silicon, aluminum, tungsten, molybdenum, and beryllia.

4. A package, as defined in claim 1, wherein the thermally conductive material is selected from a group that includes pure materials, compounds, and composites of silver, copper, diamond, silicon, aluminum, tungsten, molybdenum, and beryllia.

5. A package, as defined in claim 1, further comprising:

a die that is thermally connected to the slug; and

an optically transparent material, encapsulating the die, having a hardness less than Shore 10A.

6. A package, as defined in claim 1, further comprising:

a die that is thermally connected to the slug; and

an optically transparent encapsulant that has a hardness of at least Shore 50D.

7. A die assembly, as defined in claim 5, further comprising a submount of thermally conductive material connected between the die and the slug.

8. A die assembly, as defined in claim 7, wherein the thermally conductive material of the slug and the submount are selected from a group that includes pure materials, compounds, and composites of silver, copper, diamond, silicon, aluminum, tungsten, molybdenum, and beryllia.

9. A die assembly, as defined in claim 5, wherein the thermally conductive material of the slug and the submount are selected from a group that includes pure materials, compounds, and composites of silver, copper, diamond, silicon, aluminum, tungsten, molybdenum, and beryllia.

10. A die assembly, as defined in claim 5, further comprising a reflector cup, positioned near the slug, having a reflective surface.

11. A die assembly, as defined in claim 10, wherein the reflector cup is integrated into the leadframe.

12. A die assembly, as defined in claim 11, wherein the reflector cup is selected from a group that includes silver, aluminum, gold, silver with a dielectric coating, gold with a dielectric coating, and aluminum with a dielectric coating.

13. A die assembly, as defined in claim 12, wherein the reflective surface is selected from a group that includes silver, aluminum, gold, silver with a dielectric coating, gold with a dielectric coating, and aluminum with a dielectric coating.

14. A die assembly, as defined in claim 12, wherein the reflective surface includes at least one totally internal reflective surface formed by refractive index step changes > .3.

15. A package, as defined in claim 1, further comprising a reflector cup, positioned near the slug, having a reflective surface.

16. A package, as defined in claim 15, wherein the reflector cup is integrated into the leadframe.

17. A package, as defined in claim 16, wherein the reflector cup is selected from a group that includes silver, aluminum, gold, silver with a dielectric coating, gold with a dielectric coating, and aluminum with a dielectric coating.

18. A package, as defined in claim 17, wherein the reflective surface is selected from a group that includes silver, aluminum, gold, silver with a dielectric coating, gold with a dielectric coating, and aluminum with a dielectric coating.

19. A package, as defined in claim 17, wherein the reflective surface includes at least one totally internal reflective surface formed by refractive index step changes > 0.3.

ABSTRACT

An LED package includes a heat-sinking slug that is inserted into an insert-molded leadframe. The slug may include an optional reflector cup. Within this cup, the LED and a thermally conducting sub-mount may be attached. Wire bonds extend from the LEDs to metal leads. The metal leads are electrically and thermally isolated from the slug. An optical lens may be added by mounting a pre-molded thermoplastic lens and a soft encapsulant or by casting epoxy to cover the LED or by a cast epoxy lens over a soft encapsulant.

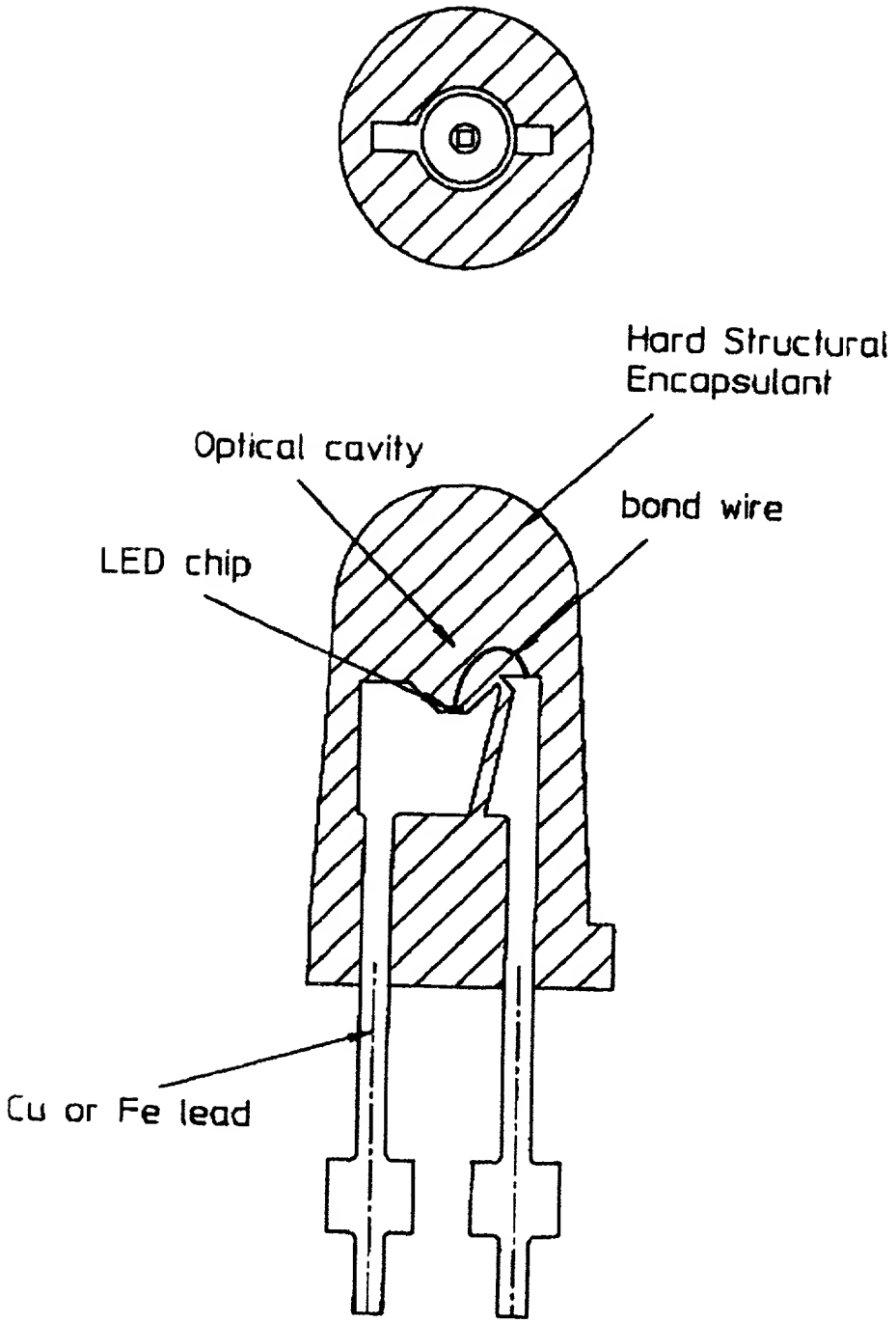

FIGURE 1 (PRIOR ART)

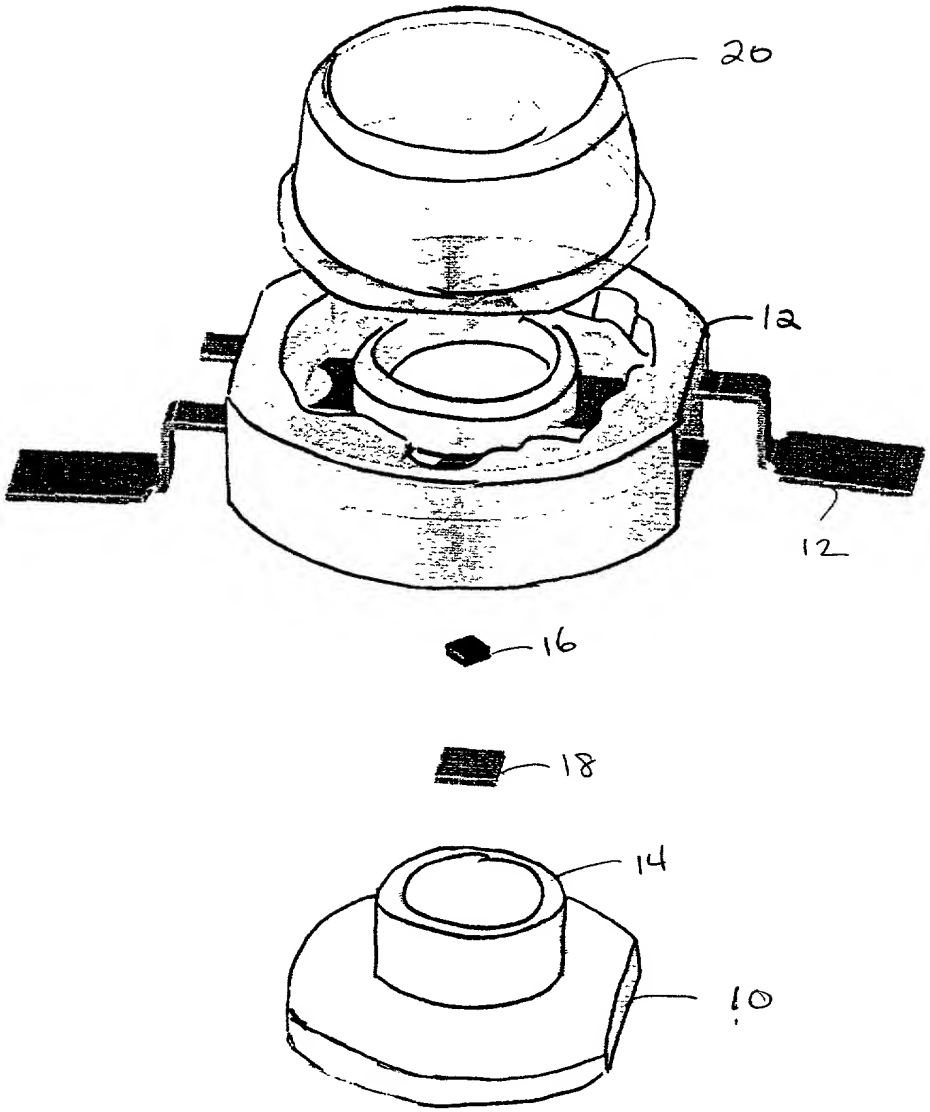

FIGURE 2

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

ATTORNEY DOCKET NO. 10971414-1

As a below named inventor, I hereby declare that:

My residence/post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

A Surface Mountable LED Package

the specification of which is attached hereto unless the following box is checked:

( ) was filed on_____as US Application Serial No. or PCT International Application Number _____ and was amended on_____ (if applicable).

I hereby state that I have reviewed and understood the contents of the above-identified specification, including the claims, as amended by any amendment(s) referred to above. I acknowledge the duty to disclose all information which is material to patentability as defined in 37 CFR 1.56.

Foreign Application(s) and/or Claim of Foreign Priority

I hereby claim foreign priority benefits under Title 35, United States Code Section 119 of any foreign application(s) for patent or inventor(s) certificate listed below and have also identified below any foreign application for patent or inventor(s) certificate having a filing date before that of the application on which priority is claimed:

COUNTRY	APPLICATION NUMBER	DATE FILED	PRIORITY CLAIMED UNDER 35 U.S.C. 119
			YES: ___ NO: ___
			YES: ___ NO: ___

Provisional Application

I hereby claim the benefit under Title 35, United States Code Section 119(e) of any United States provisional application(s) listed below:

APPLICATION SERIAL NUMBER	FILING DATE

U. S. Priority Claim

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, Section 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

APPLICATION SERIAL NUMBER	FILING DATE	STATUS (patented/pending/abandoned)

POWER OF ATTORNEY:

As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) listed below to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Julian A. Carey
Inventor's Signature

11/5/98
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DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION (continued)

ATTORNEY DOCKET NO. 10971414-1

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William David Collins III — 5 Nov. 1998

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Inventor's Signature — Date

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Post Office Address: _____

_____ _____

Inventor's Signature — Date

Full Name of # 6 joint inventor: _____ Citizenship: _____

Residence: _____

Post Office Address: _____

_____ _____

Inventor's Signature — Date

Full Name of # 7 joint inventor: _____ Citizenship: _____

Residence: _____

Post Office Address: _____

_____ _____

Inventor's Signature — Date

Full Name of # 8 joint inventor: _____ Citizenship: _____

Residence: _____

Post Office Address: _____

_____ _____

Inventor's Signature — Date